REPLY TO 'THE RELATIONS BETWEEN CHROMOSPHERIC FEATURES AND PHOTOSPHERIC MAGNETIC FIELDS' BY E. N. FRAZIER

(Research Note)

PETER FOUKAL and HAROLD ZIRIN
Big Bear Solar Observatory, California Institute of Technology, 212 Robinson, Pasadena, Calif. 91109, U.S.A.

(Received 5 May, 1972)

Frazier (1972) has criticized the conclusions of Zirin (1971, 1972), Veeder and Zirin (1970), and those of Foukal (1971a, b, c) on the relation between Hα structure and magnetic fields. We wish to reply to these criticisms.

Some of the points Frazier mentions refer to statements made by Veeder and Zirin (1970) based on low resolution magnetograms and medium resolution Hα pictures. These statements were based on the best magnetograms available at the time and have already been corrected in a more recent paper to which Dr Frazier has access (Zirin, 1972). Dr Frazier actually has a similar difficulty in that his Hα pictures do not have sufficient resolution to derive full information from his magnetograms.

Our remarks on the general relation between Hα brightness and longitudinal field strength (Zirin, 1972) are based on comparison with photoelectric magnetograms from Mt Wilson (fine scans) and Kitt Peak. Presumably these are better calibrated than photographic systems such as used by Frazier or video systems such as used by Jansens (1972), and they in fact show a dependence of Hα brightness on longitudinal field strength. Of course, as finer details are uncovered, deviations will appear, as Hα intensity also depends somewhat on rate of change of the field. Also, near active regions, some regions of enhanced field are covered by dark fibrils in centerline Hα and only appear in off-band or K-line pictures. K-line pictures are very sensitive to longitudinal B but do not show transverse fibrils very well. However, in general all regions of longitudinal field above 25 G produce a discernible effect in Hα, usually a brightening in centerline and a darkening in the wing.

Frazier's statement that the correspondence between fibrils and field breaks down in active regions is not borne out by his picture. In the strong field region the fibrils which outline the rim of the plage correspond quite closely to the magnetic field in his magnetogram. They seem packed together only on his relatively low resolution Hα picture. Good Big Bear Solar Observatory pictures show the individual structure of each such AR fibril with little ambiguity. The example given of a 'missing plage' seems to contain a small spot or pore – it should be examined further off-band to tell for sure.

We feel that Frazier's examples, even using Hα pictures that are not state of the art,

Solar Physics **26** (1972) 148–150.

actually underline the strong correspondence between Hα features and magnetic features. We have found that this correspondence gets even more striking when better Hα is available.

Frazier also undertakes to refute several conclusions reached by Foukal in a series of recent papers (Foukal, 1971a, b, c). He presents as evidence a series of 'counter examples' to the relationships derived in those papers. We wish to examine those counter examples in detail below.

(1) Frazier's statement that "there is no proof whatsoever that fibrils follow field lines" is misleading. It ignores the considerable observational evidence in favor of this hypothesis. Although the evidence is not yet conclusive it certainly deserves mention since Frazier is unable to produce any observations which would argue against the model of these structures proposed by Foukal (1971a, b, c).

(2) The definition of threads as proposed by Foukal (1971b, c) differs from that of earlier authors precisely in recognizing that the length of the feature is immaterial. Prata (1971) has documented how threads and filaments cannot be distinguished with insufficient Hα resolution. Frazier's 'counter example' (Figure 4) is meant to show a thread-like feature which does not connect opposite polarities. In fact examination of the picture shows that while one end of the thread is associated obviously with a given polarity, the other end terminates in a region where the magnetogram shows no well defined polarity at all. Neighboring features in the magnetogram are of both polarities, so the thread could connect to either polarity just below the limit of the magnetogram's sensitivity. Thus this 'counter example' proves nothing.

(3) Frazier uses the statement that "fibrils and threads avoid like polarity" to deduce the wrong polarity in an active region. This statement cannot be used that way; it would imply that all polarity on the sun to which a fibril does not stream is like polarity – clearly a nonsensical result. Taken in its context (Foukal ,1971c), the statement merely points out that in a field of fibrils of well-defined direction it often occurs that a particular fibril markedly changes direction to avoid an element of plage. Examination of a magnetogram in such a case invariably shows that the plage was of like polarity. If Frazier had used the simple rule that filaments divide opposite polarity and recognized that the threads give no information at all about large regions to which they do not connect, he would have derived the correct polarity with no ambiguity.

The examples given in Figure 4 simply show three perfectly clear examples of AR filaments – running along neutral lines as shown by the magnetograms and recognizable as such in high resolution Hα. They do not present any problem of identification as suggested by Dr Frazier.

(4) Frazier claims that the antiparallel streaming of fibrils on opposite sides of a neutral line is coincidental or irrelevant. As pointed out clearly in a review paper (Foukal, 1971c) to which Dr Frazier has access, the rule holds true at every one of the very many neutral lines where fibrils on both sides have a recognizable sense of streaming. Foukal has shown that it can be used to predict neutral lines where there are no filaments. Dr Frazier merely gives one example of a case where the fine structure

on one side does not have any recognizable sense of streaming, a case noted by Foukal, which in no way disproves the statement of the rule.

The separate question of the field geometry within filaments which may not be directly related to the behavior of the fibrils and spicules near the neutral line is also discussed in the same paper (Foukal, 1971c). It is suggested that the case of field axial to the filament mentioned in Foukal (1971a) may be one of a number of possibilities of which the traditional Kippenhahn-Schlüter geometry is another particular case.

(5) We recognize of course that the statement $B_{\|} + \mathrm{H}\alpha \rightarrow B$ will remain a controversial assumption until proven rigorously either by a reliable vector magnetograph or by comparison on the disk of Hα and X-ray coronal fine structure which can perhaps be shown to be current-free as well as force-free. However, we fail to see what evidence there is for Dr Frazier's statement that the above assumption is more plausible in the case of the chromospheric AFS which he has studied than for the chromospheric threads and fibrils which we have investigated.

There now exists a certain amount of interesting evidence both leading to and successfully derived from the hypothesis that fibrils and threads follow a subset of field lines. This evidence as given in the papers referenced below, is derived by comparing the best Aerospace or Kitt Peak magnetograms with Big Bear Solar Observatory Hα pictures whose resolution greatly exceeds those used in Frazier's article.

As pointed out above, Dr Frazier's treatment of his data on the field in AFS is no more or less rigorous than our approach to accumulating evidence on the field in threads, fibrils and filaments. In view of this, we feel that his preoccupation with dialectical rigor in his article is out of place and serves merely to obscure the important point that his 'counterexamples' completely fail to disprove any of our observational evidence.

While the hypotheses we have stated above are not rigorously proved by our evidence, the specific use of some rules (Zirin, 1972) derived from this evidence to predict the field structure in an AR is best consided on its own merits. The ability to predict magnetograms from Hα pictures is a real test of the rules.

This in fact has been done successfully (Zirin, 1972) in a case where the magnetogram was not available to us until the prediction was submitted to Dr J. Harvey. We undertake to do the same for Dr Frazier if he has unpublished magnetograms for a day on which Big Bear pictures are available.

References

Foukal, P.: 1971a, *Solar Phys.* **19**, 59.
Foukal, P.: 1971b, *Solar Phys.* **20**, 298.
Foukal, P.: 1971c, unpublished BBSO preprint, 'The Relation between Chromospheric Structure, Magnetic Field and Filaments', based on invited review at Capri Conference 1971.
Frazier, E. N.: 1972, *Solar Phys.* **24**, 98.
Janssens, T. J.: 1972, Aerospace Corporation preprint.
Prata, S.: 1971, *Solar Phys.* **20**, 310.
Veeder, G. J. and Zirin, H.: 1970, *Solar Phys.* **12**, 391.
Zirin, H.: 1971, *Phil. Trans. Roy. Soc. London* A **270**, 77–80.
Zirin, H.: 1972, *Solar Phys.* **22**, 34–48.